CHAL-0508
COPY 1 OF 2

Engineering Report Number 5201

TITLE: Proposal - Feasibility Prototype For 52.5 Inch f/3.5 Maksutov Type Aerial Camera.

DATE: January 6, 1958

PREPARED FOR: Projector

PREPARED BY: JDW, PF, JC.

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Approved: [redacted]

January 6, 1958

Proposal For A Lightweight Long Focal Length Optical System For Photographic Use

Introduction

The existing ALF optical system, although capable of recording an unusual amount of specific information, is bulky, heavy, and difficult to manufacture due to the large number of optical elements. Many optical systems designed for aerial reconnaissance in recent years are film-limited. With the advent of new films, such as Eastman Kodak SO 1213, it seems probable that optical systems can be designed and produced which will record a greater amount of specific information per pound and per cubic foot than has been previously possible.

In thinking about the problem of trying to replace ALF with a lighter weight system, we have concluded that advantage must be taken of the higher resolving power of the newer films. A brief study of the problem indicates that an optical system having a focal length of the order of 52.5 inches, using a five inch film with a 4 1/2 x 4 1/2 inch format, shows sufficient promise to warrant further study and experimentation. This proposal calls for the design and manufacture of what might be termed a feasibility prototype. The intent is to build an optical system for test purposes, to test the system to determine whether or not the desired resolution can be obtained, and to summarize the results of our findings with recommendations and suggestions for further work if the results indicate that we are on the right track.

Analysis Of The Problem

The weight of an optical system tends to increase rapidly with increasing focal length, assuming that the field of view and relative aperture remain the same. The weight of the optics, for example, tend to increase as the cube of the actual aperture. The weight of the film increases as the square of the focal length, assuming that the field of view remains constant. The weight of other components of the system also tend to increase with increasing focal length.

Since the ALF system is already as large as can be tolerated and is undesirably heavy, it seems obvious that a shorter focal length system is needed. However, if one decreases the focal length, resolution on the film must increase proportionally in order to record the same specific information (see Figure 1). If one takes a figure of 40 l/mm for the ALF system, which has a 180 inch focal length, then it becomes apparent that a system of shorter focal length would be comparable in specific information content when, for example, a 120 inch system has 60 l/mm resolution, a 72 inch system has 100 l/mm resolution, and a 60 inch system has 120 l/mm resolution.

Because of the above relation between resolution and focal length for equal information content, and the additional relation between focal length and weight of the system, it seems logical to assume that the shortest focal length system which can be used should be chosen.

In order to maintain the required resolution for the shorter focal length system, it is important to properly select the film type so as not to limit resolution capability thereby. In general it is necessary, in order to obtain high resolution, to use a fine grain and consequently a slower film. Therefore, it follows that a faster system than ALF, to accommodate the slower film, would be necessary.

After weighing the various factors which affect weight, it appeared that a system having a focal length of 52.5 inches, covering a 4 1/2 x 4 1/2 inch format, would be close to optimum. The required resolution would be in the order of 135 l/mm, and the resulting field of view of approximately 4.3° would be essentially the same as ALF.

Fortunately, at least one of the new film developments of which we are aware indicated the possibility that such resolution is probably obtainable, at least on paper. We refer specifically to Eastman Kodak SO 1213 which, according to information obtained from the Sensitometric Branch at Wright Field, has excellent antihalation characteristics, an exposure index of ASA 8, and resolves approximately 150 l/mm as tested at Wright Field with a sensitometer having a 3,000 to 1 brightness ratio and using the standard Air Force target with an aspect ratio of 5 to 1, developed as recommended by the manufacturer. We understand this particular film can be under-exposed considerably. We also understand this film has excellent contrast characteristics against low contrast objects and, therefore, can be exposed without the benefit of a yellow filter if desired.

Optical System

In examining the various optical systems we know of, we concluded that a variation of the Maksutov telescope would merit consideration in this application. The field of view and resolution which can be obtained, at least on paper, is very encouraging. The system lends itself to being folded in a variety of shapes which could be fitted to the particular application. The system has a relatively small number of glass elements which should help considerably in manufacture and alignment. Furthermore, all surfaces would be spherical or plano. The attached sketches, Figures 2 through 7, show various configurations to which the system could be adapted.

The value of minimal weight in airborne equipment has become a matter of prime importance. Means to accomplish this minimal weight were studied in great detail and were exemplified, in part, by our production of a lightweight cone of radical design. This cone incorporated modern materials and techniques which had hitherto been neglected in practical application. Its fabrication culminated with a structural weight of only 35% the weight of the equivalent conventional cone.

Among the most massive elements in the system under consideration are the two mirrors. In order to reduce weight to a minimum, use can be made of techniques such as a quartz-foam backed quartz plate. This is a thin slab of quartz fused to a thick backing layer of quartz foam. This method has proved extremely effective in reducing the weight of first surface reflecting elements.

With regard to the cell mounting itself, an additional attractive feature of the optical system proposed is that it can be mounted in a sturdy, lightweight cell.

In spite of the increased rigidity required for a reflective as compared to a refractive system, our experience indicates that a scheme such as the use of a stainless steel, conical spinning would be satisfactory for the cone.

Applying our engineering know-how to the system under present consideration, it seems probable that weight could be kept fairly low. We have roughly estimated the weight of a complete system and feel it would be possible to keep it under 300 pounds, with a 250 pound design objective.

<u>Proposal</u>

Based upon preliminary considerations of the Maksutov-type system, the space and weight limitations, and the performance requirements necessary, we are proposing a specific design as the basis of a feasibility prototype. This design is outlined in Figure 8. As stated previously, this feasibility prototype would essentially be built to establish the soundness of design optically, with regard only to resulting image. No attempt will be made in this model to achieve lightweight construction, or to incorporate film drive, IMC, or any other area not directly related to optical imagery. A model or prototype would be constructed to determine whether or not the system itself is inherently capable of producing the required resolution.

The proposed system would have a focal length of 52.5 inches, and a speed of f/3.5. Besides allowing for slower films and/or faster exposures, additional advantages are gained by using this relatively fast system. Unlike the ALF which is diffraction limited to approximately 125 l/mm, this system would be film limited, the diffraction limit being well in excess of that obtainable on film. In addition, the faster system would permit higher shutter speeds, materially simplifying the IMC problem. Speeds in the order of 1/1000 second have been considered as possible with this system.

Coincidentally, choice of this particular focal length and speed permits the use of existing glass blanks, which will expedite production of the proposed prototype.

The very nature of the Maksutov-type optical system is such as to predict very little effective residual aberration in the image, and very good resolution and definition across the field. A field flattener will be used to enable the use of a flat film platen, as well as to remove astigmatism.

A 4.5 x 4.5 inch film format will be covered in this design, with a resultant field of view somewhat in excess of 6° along the diagonal.

We plan to test the system photographically using an improvised photographic system employing a standard camera back from a camera such as the Speed Graphic or the Linhof Technika.

A final report will be prepared summarizing the results of tests and making recommendations for future courses of action. In the event that the results indicate that it is feasible to replace ALF with this system, the report will contain a layout and cost estimate for such a system.

EQUIVALENT INFORMATION CONTENT
FOCAL LENGTH VS. RESOLUTION

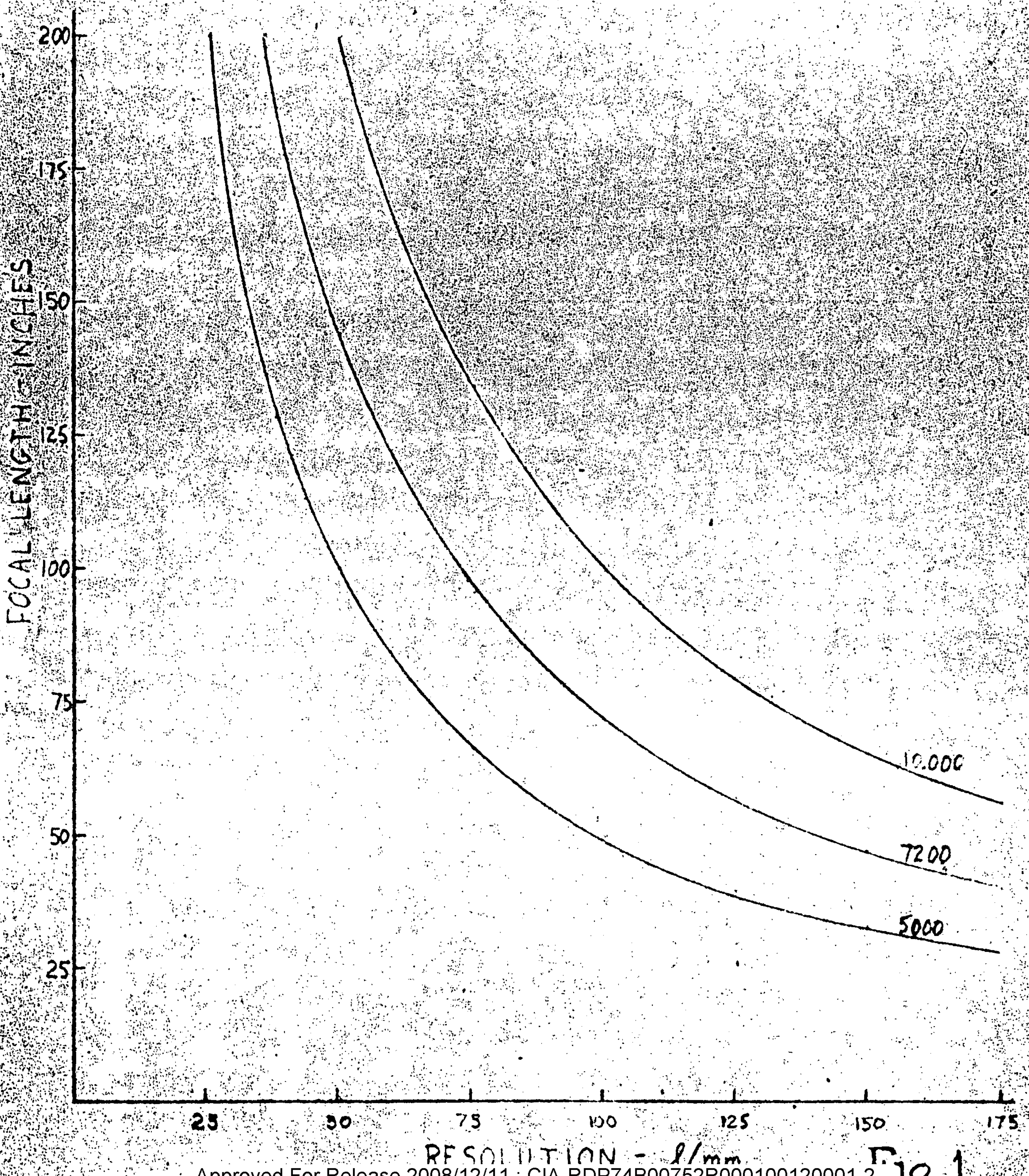

Fig. 1

TOLERANCES UNLESS OTHERWISE SPECIFIED
THREE PLACE DECIMALS ± .003
FRACTIONAL DIMENSIONS ± 1/32
TWO PLACE DECIMALS ± .010
ANGULAR DIMENSIONS ± 1/2°

DIAMETERS MUST BE CONCENTRIC WITHIN .005 F.I.R.
SHARP CORNERS TO BE .005 MAX. RADIUS.
TO BE SMOOTH MACHINE FINISH AND FREE OF BURRS.
CHAMFERS NOT DIMENSIONED TO BE .02 X 45°

DRAWING NO.

CHANGES		
CHGD. BY	DATE	CHANGE NO.

CHANGE

52.5" f/3.5 4.9° MAKSUTOV SYSTEM

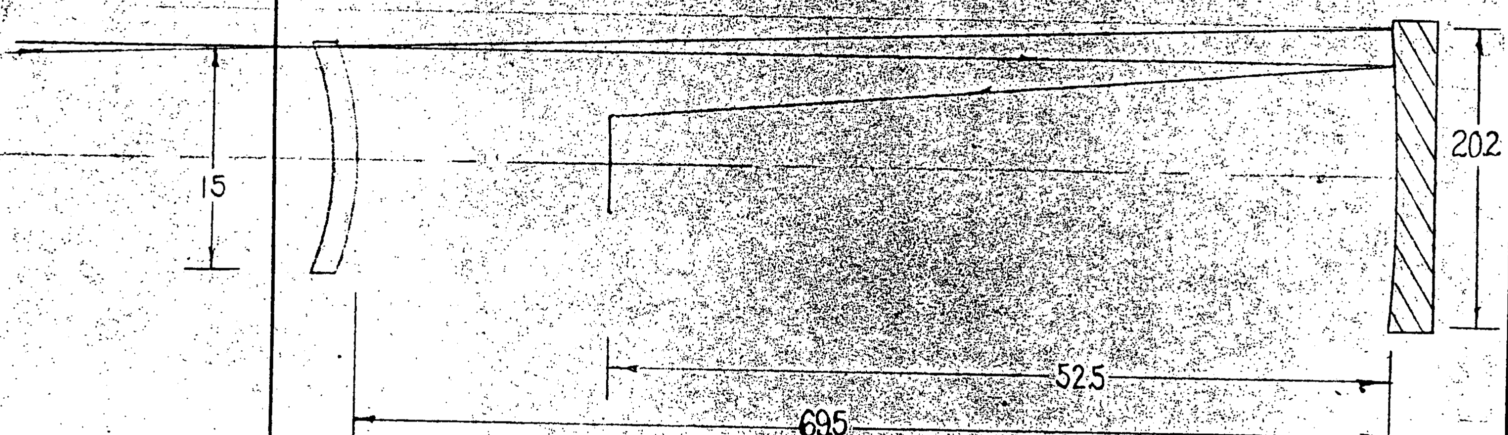

Fig. 2

NEXT ASSEM.	QUAN.	MATERIAL
		TREATMENT
		FINISH

SCALE 1/10
DRAWN R. FORMAN DATE 1/2/58
CHECKED DATE
PROJ. ENG. DATE
ENGINEERING RELEASE NO.

[redacted]

NAME 52.5" f/3.5 4.9° FIELD MAKSUTOV
DRAWING NO.
CHANGE

TOLERANCES UNLESS OTHERWISE SPECIFIED

THREE PLACE DECIMALS ± .003
FRACTIONAL DIMENSIONS ± 1/32
TWO PLACE DECIMALS ± .010
ANGULAR DIMENSIONS ± 1/2°

DIAMETERS MUST BE CONCENTRIC WITHIN .006 F. I. R.

SHARP CORNERS TO BE .005 MAX. RADIUS.

UNLESS SPECIFIED ALL PARTS TO BE SMOOTH MACHINE FINISH AND FREE OF BURRS.

CHAMFERS NOT DIMENSIONED TO BE .02 X 45°

DRAWING NO.

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52.5" f/3.5 90° FOLDED MAKSUTOV-TYPE
AERIAL CAMERA

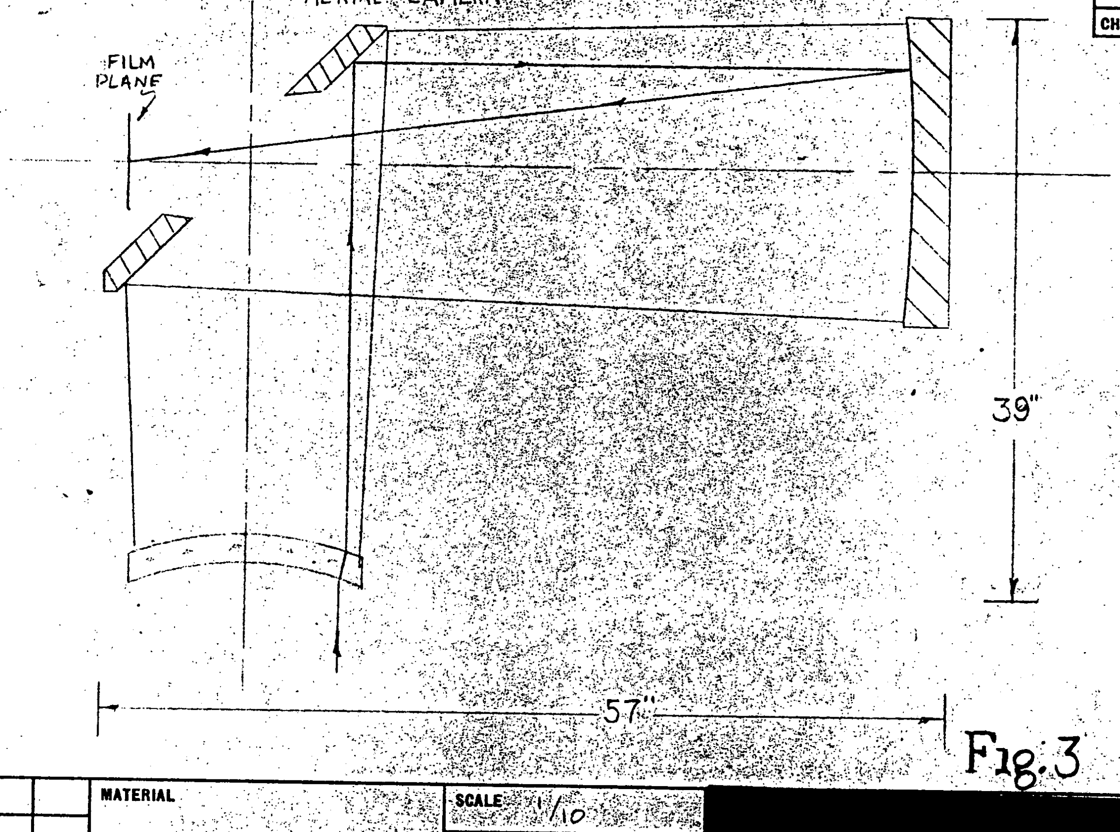

Fig. 3

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	PROJ. ENG.	DATE	
FINISH	ENGINEERING RELEASE NO.		DRAWING NO.

NEXT ASSEM. | QUAN.

CHANGE

TOLERANCES UNLESS OTHERWISE SPECIFIED

THREE PLACE DECIMALS ± .003 — TWO PLACE DECIMALS ± .010
FRACTIONAL DIMENSIONS ± 1/32 — ANGULAR DIMENSIONS ± 1/2°

DIAMETERS MUST BE CONCENTRIC WITHIN .005 F. I. R.
SHARP CORNERS TO BE .005 MAX. RADIUS.
TO BE SMOOTH MACHINE FINISH AND FREE OF BURRS.
CHAMFERS NOT DIMENSIONED TO BE .02 X 45°

DRAWING NO.

CHANGES

CHGD. BY	DATE	CHANGE NO.

CHANGE

52.5" f/3.5 DOUBLE FOLDED MAKSUTOV-TYPE
AERIAL CAMERA

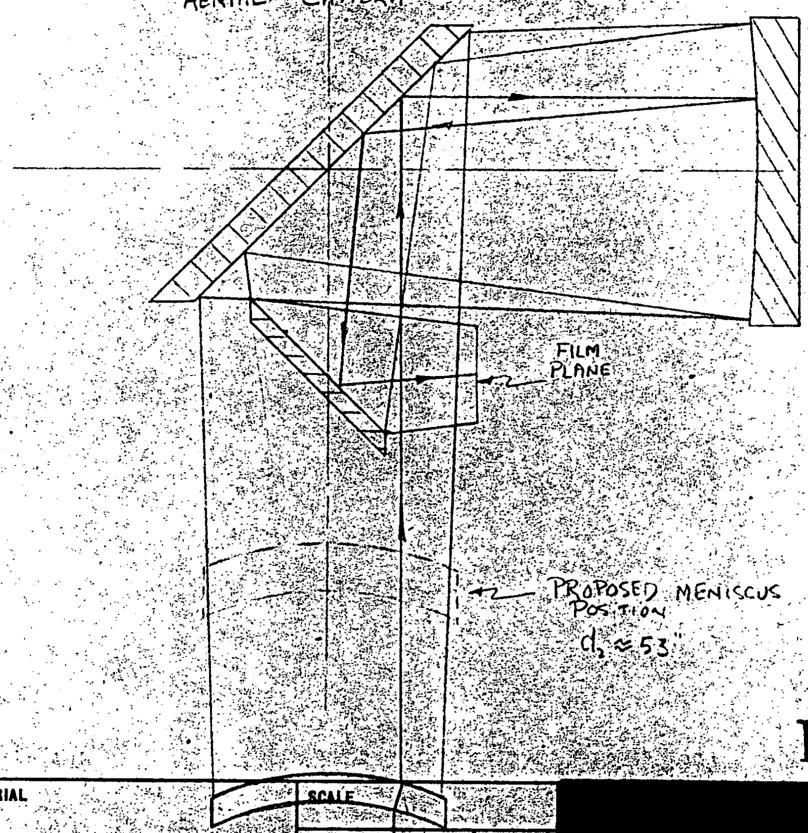

Fig. 4

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FINISH	ENGINEERING RELEASE NO.	
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NAME 52.5" f/3.5 AERIAL CAMERA

DRAWING NO.

CHANGE

TOLERANCES UNLESS OTHERWISE SPECIFIED

THREE PLACE DECIMALS ± .003 TWO PLACE DECIMALS ± .010

FRACTIONAL DIMENSIONS ± 1/32 ANGULAR DIMENSIONS ± 1/2°

SHARP CORNERS TO BE .005 MAX. RADIUS. AND FREE OF BURRS.

CHAMFERS NOT DIMENSIONED TO BE .02 X 45°

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40" f/2 MAKSUTOV SYSTEM

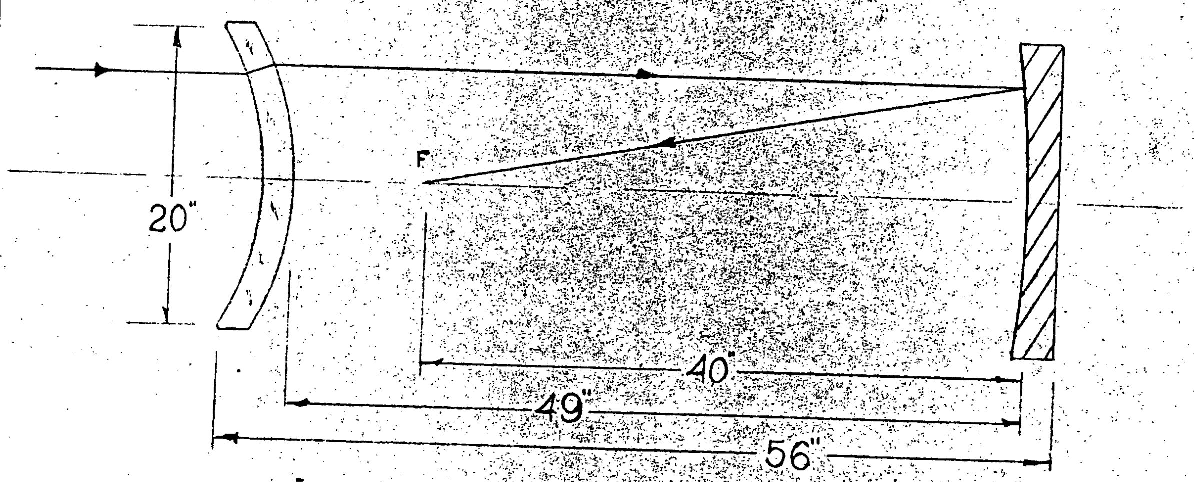

Fig. 5

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TREATMENT	CHECKED	DATE
	PROJ. ENG.	DATE
FINISH	ENGINEERING RELEASE NO.	
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NAME 40" f/2 MAKSUTOV SYSTEM

DRAWING NO.

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TOLERANCES UNLESS OTHERWISE SPECIFIED
THREE PLACE DECIMALS ± .003 — TWO PLACE DECIMALS ± .010
FRACTIONAL DIMENSIONS ± 1/32 — ANGULAR DIMENSIONS ± 1/2°

UNLESS SPECIFIED ANY TWO DIAMETERS MUST BE CONCENTRIC WITHIN .006 F.I.R.

SHARP CORNERS TO BE .005 MAX. RADIUS.

UNLESS SPECIFIED ALL PARTS TO BE SMOOTH MACHINE FINISH AND FREE OF BURRS.

CHAMFERS NOT DIMENSIONED TO BE .02 X 45°

DRAWING NO.

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CHANGE

40" f/2 90° FOLDED MAKSUTOV-TYPE AERIAL CAMERA

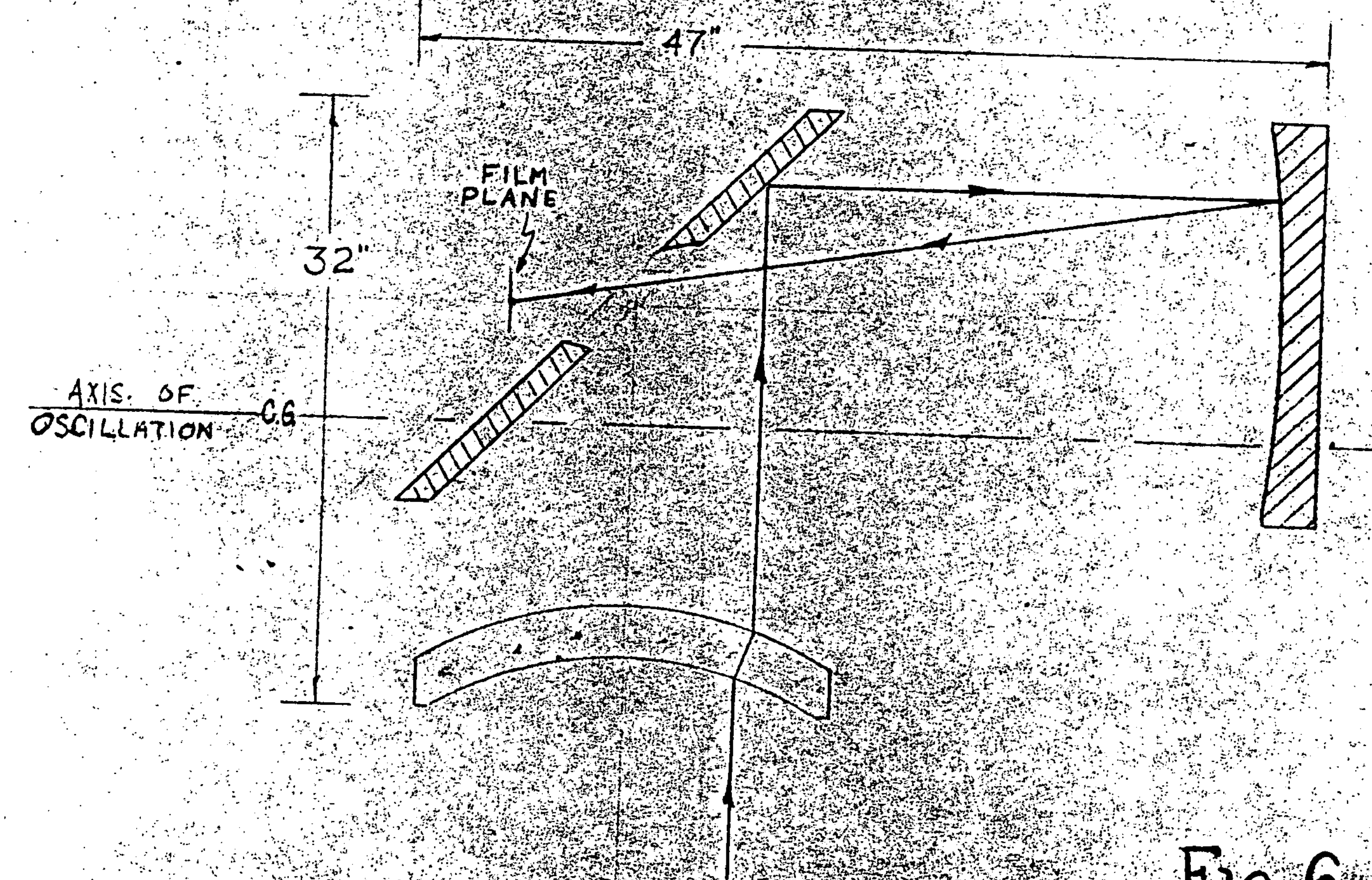

Fig. 6

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FINISH	PROJ. ENG.	DATE	
NEXT ASSEM. / QUAN.	ENGINEERING RELEASE NO.		DRAWING NO.

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Approved For Release 2008/12/11 : CIA-RDP74B00752R000100120001-2

TOLERANCES UNLESS OTHERWISE SPECIFIED	UNLESS SPECIFIED ANY TWO DIAMETERS MUST BE CONCENTRIC WITHIN .005 F.I.R.	UNLESS SPECIFIED ALL PARTS TO BE SMOOTH MACHINE FINISH AND FREE OF BURRS	DRAWING NO.
THREE PLACE DECIMALS ± .003 TWO PLACE DECIMALS ± .010 FRACTIONAL DIMENSIONS ± 1/32 ANGULAR DIMENSIONS ± 1/2°	SHARP CORNERS TO BE .005 MAX. RADIUS.	CHAMFERS NOT DIMENSIONED TO BE .02 X 45°	

CHANGES		
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40" f/2 120° FOLDED
MAKSUTOV-TYPE AERIAL CAMERA

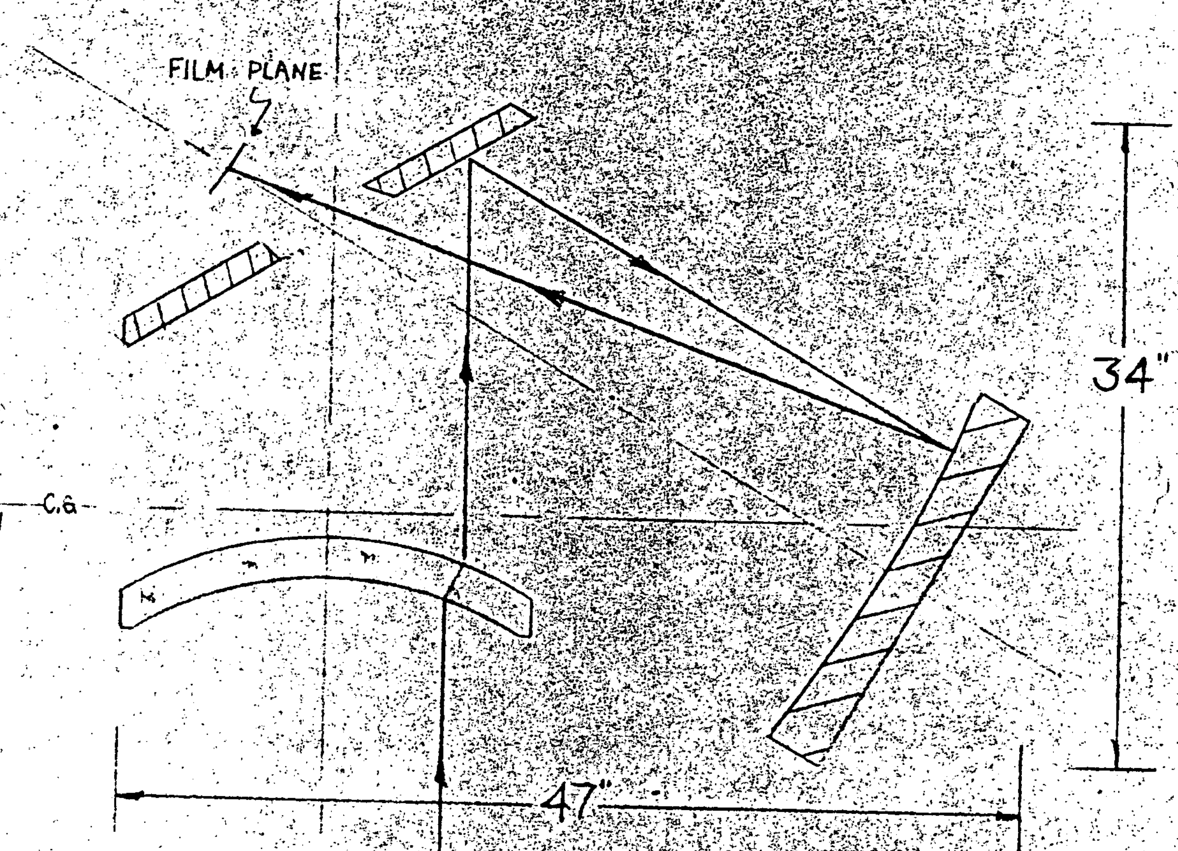

Fig. 7

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	PROJ. ENG.	DATE		
FINISH	ENGINEERING RELEASE NO.		DRAWING NO.	CHANGE
NEXT ASSEM.	QUAN.			

TOLERANCES UNLESS OTHERWISE SPECIFIED
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52.5" f/3.5 MAKSUTOV-TYPE AERIAL CAMERA

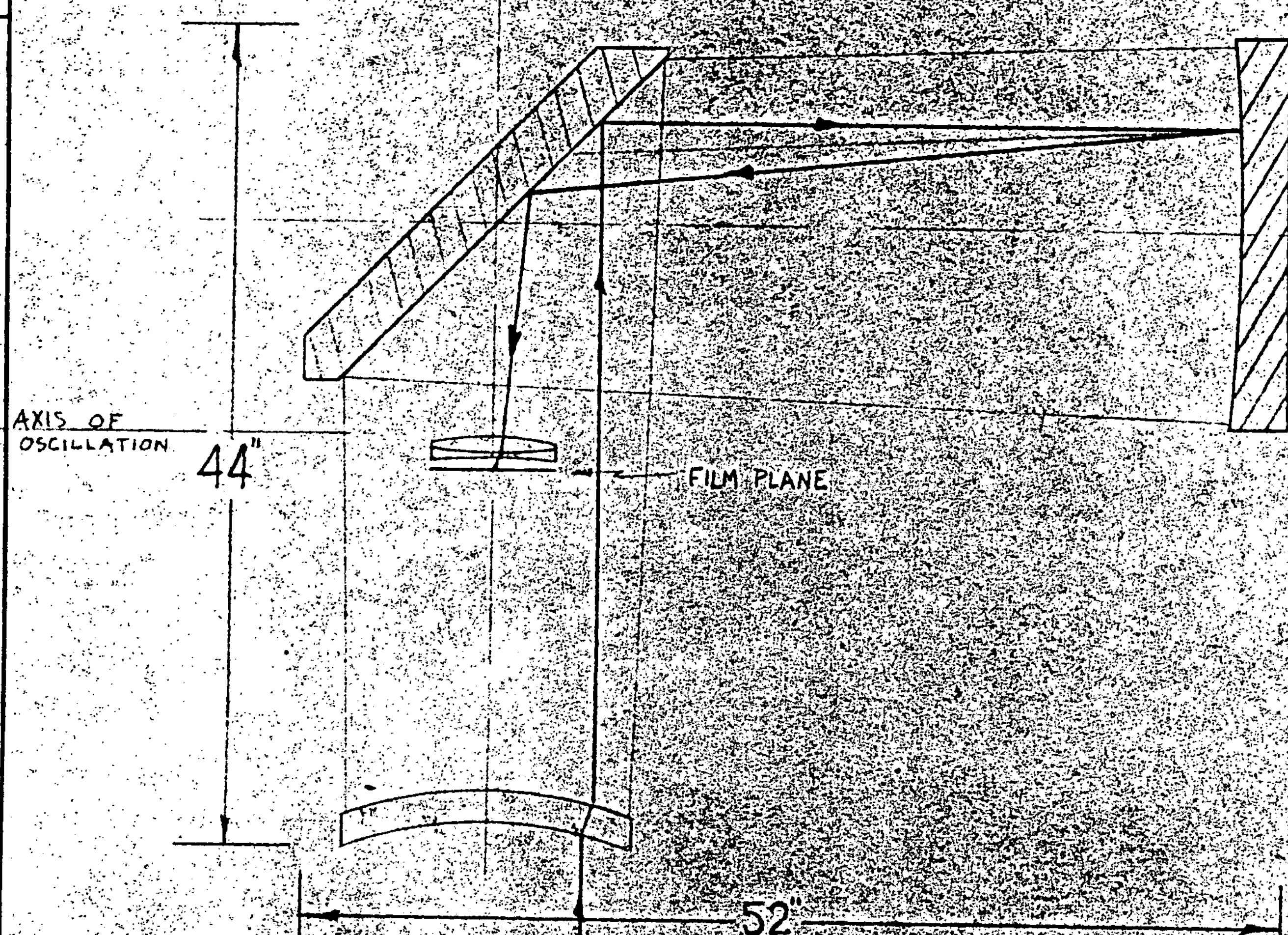

Fig. 8

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	PROJ. ENG. / DATE	
FINISH	ENGINEERING RELEASE NO.	DRAWING NO.
NEXT ASSEM. / QUAN.		CHANGE